



NATIONAL RADIO ASTRONOMY OBSERVATORY

520 EDMONT ROAD CHARLOTTESVILLE, VA 22903-2475

TELEPHONE 434-296-0211 FAX 434-296-0278

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of)	
)	
Unlicensed Operation in the TV Broadcast Bands)	ET Docket No. 04-186
)	
Additional Spectrum for Unlicensed Devices)	
Below 900 MHz and in the 3 GHz Band)	ET Docket No. 02-380

Comments of the
National Radio Astronomy Observatory
Charlottesville, VA 22903

I. Introduction

1. The National Radio Astronomy Observatory (NRAO) is pleased to provide comments responding to the Commission's First Report and Order and Further Notice of Proposed Rule Making, FCC 06-156.
2. NRAO (<http://www.nrao.edu>), operated by Associated Universities, Inc., (<http://www.aui.edu>) under a cooperative agreement with the National Science Foundation, is the largest radio astronomy observatory and one of the largest astronomical observatories of any kind in the world. It operates stations within the National Radio Quiet Zone and in more than one dozen rural locations within the United States, all of which stand to be affected by the Commission's rules for the operation of unlicensed devices within the TV broadcast bands, *aka* TV band devices.
3. In its prior comments in this Docket, on the Commission's Notice of Proposed Rule Making FCC 04-113, NRAO discussed a very broad range of concerns arising from the large frequency span of the TV broadcast allocation. In particular, in its previous Comment:
 - a. At 6-7, NRAO requested that the Commission craft rules which would preserve the usefulness of the radio astronomy allocations at 74 MHz (between TV broadcast channels 4 and 5) and at 608-614 MHz in what

would otherwise be channel 37. NRAO appreciates that the Commission's First Report and Order reserves the use of channel 37 for radio astronomy and medical telemetry.

- b. At 8, NRAO noted many coincidences between protected radio astronomy bands and low-order harmonics of frequencies within various TV channel allocations; an updated summary of such coincidences appears in Table 1 here; *the potential for detrimental interference to the telescope is particularly great in these cases*¹.

TABLE 1
TV CHANNEL HARMONICS FALLING IN PROTECTED ASTRONOMY BANDS

BAND CENTER (MHZ)	CHANNEL	HARMONIC	FOOTNOTE US. 74.794(b)
1157	5	2	311-312
325	5	4	246
408	6,11-12	5,2	74
611	11-12	3	246
1375	48-51	2	311
1413	14	3	246
1612	25	3	342
1665	27-28	3	246
1720	31	3	311
2695	47-48	4	246

4. The present Comment from NRAO is based on two additional calculations:
 - a. We compare the proposed *in-band* emission levels for TV band devices with the coordination thresholds for fixed transmitters operating at like frequencies within the National Radio Quiet Zone, host to NRAO's Robert C. Byrd Green Bank Telescope (see below at 5-8). We find that interference-free operation of the telescope can be ensured only with strong shielding of the astronomy site, indicating that fixed TV band devices installed within the NRQZ should be coordinated as for fixed, licensed transmitters.
 - b. We compare proposed Part 15.209 limits on *unwanted* emissions from TV band devices with the ITU-R Rec. RA. 769 thresholds for detrimental interference to protected radio astronomy bands at 73 – 74.6 MHz and 608 – 614 MHz; a lengthier series of calculations with similar results could be performed for the radio astronomy bands and harmonic coincidences shown in Table 1 above. The comparison shows (10-15) that compatibility is assured only with strong shielding of radio astronomy sites. Some

¹ 47 CFR 74.794(b) provides a specific example whereby RNSS is explicitly protected from harmonic unwanted emissions of low power TV and TV translator stations operating on certain TV channels.

possible means of assuring compatibility with the panoply of fixed and personal/portable devices operating under Part 15.209 limits are discussed in this Comment at 16 and beyond.

II. Operation of Fixed TV Band Devices within the National Radio Quiet Zone

5. The new rules for fixed TV band devices allow a maximum eirp 6 dBW or a spectral power density **-61.8 dB W/Hz** when spread evenly over the 6 MHz (67.8 dB Hz) bandwidth of a single TV broadcast channel.
6. By comparison, the published coordination thresholds for fixed transmitter operation within the National Radio Quiet Zone, *at frequencies outside the protected radio astronomy bands delineated in ITU-R Recommendation RA. 769* are (see <http://www.gb.nrao.edu/nrqz/nrqz.html#CoordReq>)
 - 1×10^{-12} W/m² for frequencies from 54 MHz to 108 MHz
 - 1×10^{-14} W/m² for frequencies from 108 MHz to 470 MHz
 - 1×10^{-17} W/m² for frequencies from 470 MHz to 1000 MHz,over 20 kHz (43.0 dB Hz) bandwidth or, equivalently
 - -163 dB W/(m²-Hz) from 54 MHz to 108 MHz (channels 2-6)
 - -183 dB W/(m²-Hz) from 108 MHz to 470 MHz (channels 7-13)
 - -213 dB W/(m²-Hz) from 470 MHz to 1000 MHz (channels 14-51)
7. For line of sight propagation in free space, compatibility between the radiated power spectral density cited above at 5, -61.8 dB W/Hz, and the NRQZ power flux spectral density thresholds would require attenuation equivalent to free-space, isotropic spreading over separation distances
 - 32 km from 54 MHz to 108 MHz (channels 2-6)
 - 324 km from 108 MHz to 470 MHz (channels 7-13)
 - 10,300 km above 470 MHz (channels 14-51)
8. Given that an individual TV band device may in principle employ any of the channels 2-51 (except for channel 37), only the largest of these distances is relevant. However, we do not intend to argue that such large nominal separation distances should be observed; rather, they imply that some means of shielding the radio astronomy site will be necessary to achieve operation free of detrimental interference.

III. Operation of Personal/Portable TV Band Devices within the National Radio Quiet Zone

9. The rules for personal/portable TV band devices would allow a maximum eirp of 0.1 W, a factor 40 below that for fixed devices, implying 6.3 times smaller line of sight separation distances than calculated here at 7 for fixed devices. Thus the additional attenuation required for compatibility between the NRQZ thresholds and the in-band emissions of personal/portable devices corresponds to isotropic spreading over separation distances ranging upwards of 1,500 km. Again it is implied that shielding of the TV band signals from personal/portable devices would be necessary to ensure interference-free operation of the telescope.

IV. Unwanted Emissions from TV Band Devices in Protected Radio Astronomy Bands at 73-74.6 and 608-614 MHz

10. The Commission has proposed that unwanted emissions from all TV band devices be subject to the existing Part 15.209 limits, which specify maximum field strengths of 100, 150 and 200 $\mu\text{V}/\text{meter}$ at 30-88 MHz, 88-216 MHz and 216-960 MHz, respectively, measured at distances of 3 meters.
11. Within the span of the TV broadcast bands there are two astronomy bands at 73-74.6 and 608-614 MHz which are subject to footnote US246 in the US Table of Frequency Allocations (reading in part “No station shall be authorized to transmit in the following bands ...”) and to US74 (“In the bands 25.55-25.67, 73.0-74.6, 406.1-410.0, 608-614 ... MHz ... the radio astronomy service shall be protected from unwanted emissions only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates. Radio astronomy observations in these bands are performed at the locations listed in US311.”)
12. US311 references NRAO operations at the VLA and Green Bank Telescope and at 10 VLBA sites located from Hawaii to St. Croix. The non-VLBA stations (VLA and GBT) are treated together² in the following.
13. For non-VLBA operations at 74 and 608-614 MHz the Part 15.209 unwanted emission limits should be compared with the protection criteria given in Table 1 of ITU-R Recommendation RA. 769 (“Protection Criteria Used for Radio Astronomical Measurements”). The following Table 2 repeats relevant values from Part 15.209 and expresses the RA. 769 interference thresholds in terms of $\mu\text{V}/\text{m}$; that is, the threshold noise input powers of -195 and -202 dB W cited in column 7 of Rec. RA. 769 Table 1 are converted to field strength using standard formulae

² The considerations due these two NRAO telescopes are also applicable to some other non-VLB facilities mentioned in US311 but not operated by the NRAO, in particular the Arecibo Telescope.

formulae (<http://www.craf.cu/conv.htm>). The final column tabulates implied separation distances assuming a 1/r decline in the electric field strength: the final entry in each column of Table 2 is the product of 3 m and the ratio of field strength limits tabulated in the preceding two columns.

TABLE 2
FREE-SPACE SEPARATION DISTANCES FOR PART 15.209 DEVICES

— GBT, VLA —			
FREQUENCY (MHz)	FIELD STRENGTH (μV/METER)		DISTANCE(KM)
	PART 15.209	RA 769	
73–74.6	100	0.0031	96
608–614	200	0.0111	54
— VLBA —			
608–614	200	1.2475	0.5

14. Protecting the GBT and VLA radio astronomy stations while observing the Part 15.209 limits requires attenuation of the unwanted emissions by an amount equivalent to isotropic signal spreading over separation distances of 50-100 km: the attenuation needed could be increased by any aggregation of TV band devices.
15. An analogous calculation may be carried out for the VLBA stations (which do not operate in the 74 MHz band, except at Pie Town, NM) using Table 3 of ITU-R. Rec. 769 which indicates a 41 dB larger threshold input power than in Table 1 (of RA. 769). Thus, required signal attenuation and implied nominal separation distances are much less for VLBA stations, of order 1 km as shown in Table 2 here. However, for such small distances, in the very near field of the telescope, such considerations are at best only very approximate.

V. Suggested Means of Implementing Compatibility between Radio Astronomy Stations and Fixed TV Band Devices

16. As noted here at 11, there are protected radio astronomy bands within the span of the TV broadcast bands at 73 – 74.6 MHz and 608 – 614 MHz (channel 37). The Commission has proposed that TV band devices not be authorized to transmit on channel 37 and the 74 MHz band sits between channels TV channels 4 and 5. Therefore, only unwanted emissions from TV band devices would fall inside protected radio astronomy bands and so we compared the Part 15.209 limits on *unwanted* emissions with the protection criteria for these bands (at 10-15, this Comment). However, inside the National Radio Quiet Zone there are coordination thresholds for fixed transmitters over the entire range of the TV broadcast bands, and so we compared NRQZ coordination thresholds with the *in-band* emission limits for fixed TV band

devices (6 dB W maximum eirp; at 5-8) and personal/portable devices (-10 dB W; see 9).

17. The preceding discussion, based on the technical requirements for TV band devices contained in the First Report and Order shows that:

- a. Within the National Radio Quiet Zone, compatibility between NRQZ interference thresholds for fixed transmitters and *in-band* emissions of fixed TV band devices can be ensured only if the NRAO site is heavily shielded from these emissions (see 5-8).
- b. Within the National Radio Quiet Zone, compatibility between NRQZ interference thresholds for fixed transmitters and *in-band* emissions of personal/portable TV band devices can be ensured only if the NRAO site is heavily shielded from these emissions (see 9).
- c. For the VLA and GBT, as for other non-VLBA stations, compatibility between interference thresholds for protected radio astronomy bands and *unwanted* emissions of TV band devices operating under Part 15.209 can be ensured only if the radio telescope sites are heavily shielded from these emissions (see 10-14 above).
- d. For VLBA stations, compatibility between interference thresholds for protected radio astronomy bands and *unwanted* emissions of TV band devices operating under Part 15.209 can be ensured if such devices do not operate within a few km of VLBA stations (above at 15).

18. Much of the Commission's Further Notice is concerned with the means by which the service rules for TV band devices will be implemented so as to prevent interference to authorized services. For the case of radio astronomy, the situation is in some ways comparatively simple because the number of radio astronomy stations is small and the boundaries of the National Radio Quiet Zone are simply stated. The question then is how to implement the findings in 17 a-d. In outline, NRAO recommends:

- a. For fixed TV band devices:
 - i. Within the National Radio Quiet Zone, the Commission should require coordination with NRAO, as for all other fixed operations.
 - ii. For operations within 100 km of the VLA, the Commission should
 1. Require coordination with or notification of NRAO *and*
 2. Require that operation of a local ensemble of devices (FCC 06-156 at 46) respects the electric field limits derived from ITU-R Recommendation RA.769 and cited in our Table 2 at 13, at the nearest edge of the VLA site.

- iii. For operations within 3 km of VLBA stations, the Commission should
 1. Require coordination with or notification of NRAO *and*
 2. Require that operation of a local ensemble of devices (FCC 06-156 at 46) respects the electric field limits derived from ITU-R Recommendation RA.769 and cited in our Table 2 at 13, at the nearest edge of the VLBA site.

VI. Radio Astronomy Stations and Personal/Portable TV Band Devices

19. The calculations here at 10-15 show that devices obeying Part 15.209 limits on unwanted emissions should not be operated in the vicinity of radio astronomy stations absent strong shielding. In our earlier Comment we requested that the Commission require the use of smart-radio technology based on geo-location to preclude operation of personal/portable TV band devices within the NRQZ.
20. As noted in our previous filing in Docket 04-186, consumers rely on the FCC certification stickers on their gear and cannot necessarily be expected to understand, unless explicitly so informed, that there exist special circumstances in which the normal certification procedure does not ensure safe operation. Prohibitions on the use of electrical devices during aircraft takeoff and landing and on the use of cell phones in flight are examples of such special circumstances.
21. It was shown at 10-15 here that operation of TV band devices in the vicinity of radio astronomy stations at Part 15.209 levels could result in interference in protected radio astronomy bands. Although NRAO stations are remote, they are nonetheless generally accessible to the general public; the VLA and Green Bank sites are tourist destinations and the latter site (in addition to being near a small town with resident broadband users *via* DSL) now hosts a science and tour center (which is electrically shielded).
22. The NRAO does not foresee any means by which a strict separation between its stations and personal/portable TV band devices might be enforced outside site boundaries and we therefore repeat a request from our earlier Comment. We ask that the FCC require an informational bulletin to be placed in the packaging of TV band devices, indicating a) that they may negatively impact the performance of a radio telescope and b) that the operator of such equipment should be prepared to cooperate with the radio astronomy service in ameliorating such negative impact, if so requested.

VII. Additional Considerations

23. In the NPRM FCC 04-113 at 28, the Commission noted that the location and properties of fixed/access devices might usefully be registered in a database; NRAO favors the creation of a publicly-available database and recommends that the database be searchable by geo-location, among other means, and not, as for BPL, solely by postal code (see <http://www.bpldatabase.org>). NRAO also favors creation of a type database for personal/portable devices (FCC 04-113 at 24).

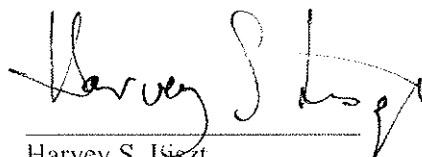
24. To date, the Commission has facilitated radio astronomy use of the channel 37 band by observing a variation of the adjacent channel rule, *i.e.* by not assigning channels 36 and 38 in the vicinity of radio astronomy stations. Protection for the radio astronomy bands at 74 MHz between TV broadcast channels 4 and 5, and in the channel 37 band, would be assisted if assignments to channels 4&5 and 36&38 were not made in the vicinity of the VLA, and if channels 36 and 38 were not assigned in the vicinity of the VLBA stations (the GBT presumably being protected by NRQZ rules).

Respectfully submitted,

National Radio Astronomy Observatory
By:



Fred K. Y. Lo
Distinguished Scientist and Director



Harvey S. Liszt
Scientist and Spectrum Manager

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Direct correspondence to:

Director
National Radio Astronomy Observatory
520 Edgemont Road
Charlottesville, VA 22903